3-II A2

A MILLIMETER WAVE INTERFEROMETER WITH A BEAM WAVEGUIDE FEED NETWORK

A. C. Schell
Microwave Physics Laboratory
Air Force Cambridge Research Laboratories
Bedford, Mass. 01730, U.S.A.

Antennas for the millimeter wave bands are usually intended for applications requiring high gain and resolution. The antenna designs are conventionally based on optical techniques, and methods of antenna arraying are not extensively developed. The use of conventional waveguide or similar transmission structures usually results in losses per unit length of the order of 0.1 dB/cm.

A method of electromagnetic power transmission that appears particularly suitable to millimeter wave arraydesign is the beam waveguide. First described by Goubau and Schwering[1], beam waveguide techniques have been applied to the design of a primary radiator for a cassegrain antenna[2] and the transmission line to a scanning paraboloidal antenna[3]. Beam waveguides can also be used for an array feed system with almost the same flexibility and control as is the case with conventional waveguide.

An antenna has been constructed at the Air Force Cambridge Research Laboratories that illustrates this technique. The antenna is an array of four paraboloidal reflectors. Each reflector is 120 cm. in diameter, and is provided with a Cassegranian subreflector 15 cm. in diameter. The subreflector is illuminated by the fields from a beam waveguide feed arranged beneath the reflectors to provide equal path lengths to each reflector aperture.

The four basic components of the beam waveguide feed are the launcher, the lens, the power splitter, and the mirror. By appropriate choices and placement of these components, millimeter wave feed networks can be designed for varied uses. Illustrated in Fig. 1 is the schematic of the equal-path feed for the AFCRL array. A high efficiency launcher is a prime requirement for the feed network, and either corrugated or dual mode horns function well in this capacity. If it is desired to produce element aperture illuminations that differ from the basic Gaussian function, higher order beam waveguide modes must be excited. For these applications a special reflector may be used as a launcher.

Lens design for the beam waveguide has been discussed elsewhere[4], and the principal concern for the millimeter wave band feed is the impedance matching at the lens surface. Techniques that have been experimentally tested are the use of

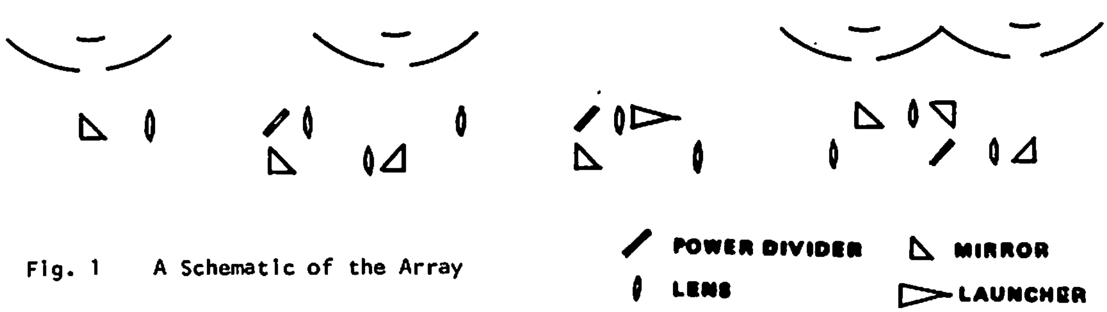

Fig. 1 A Schematic of the Array

grooves cut in the lens surface and surface layers of material with lower dielectric constant. The diameter of the lens is chosen large enough so that there is negligible diffraction loss in the basic beam waveguide mode.

For linearly polarized fields the power splitter for the array consists of a single sheet of dielectric. The thickness and dielectric constant are chosen to provide the desired power ratio. The mirrors are polished flat aluminum surfaces.

The antenna has been constructed with a massive steel support structure that rotates about an east-west line. A track similar to an optical bench permits the precise physical adjustment of feed components. Optical mensuration equipment is used to maintain accuracy of component placement. The antenna is enclosed in a temperature-stabilized shelter to avoid thermal distortions. The radomes are fabricated of a special low density plastic foam. Phase distortion of the wavefront through the radomes has been measured, and the rms phase deviation from a plane is approximately 8° at a wavelength of 2.2 mm.

A photograph of the antenna is shown in Fig. 2. The presentation will include a discussion of the theoretical and experimental results obtained concerning this antenna array.

References:

1. G. Goubau and F. Schwering, "On the Guided Propagation of Electromagnetic Wave Beams", IRE Trans. Ant & Prop., May 1961, pp 248-256

2. T. Kitsuregawa and M. Mizusawa, "Design of the Beam-Waveguide Primary Radiators of the Cassegrain Antennas for Satellite Communications" 1970 G-AP International Symposium Digest, September 1970, pp 400-406.

3. C. O. Yowell, "A Focused Aperture Millimeter Wave Transmission Line", Report No. TR-0059(6230-30)-7, The Aerospace Corp., El Segundo, Calif., November 1970.

4. G. Goubau, "Beam Waveguides", in Advances in Microwaves, Vol. 3, Leo Young, ed., Academic Press, 1968, pp 67-126.

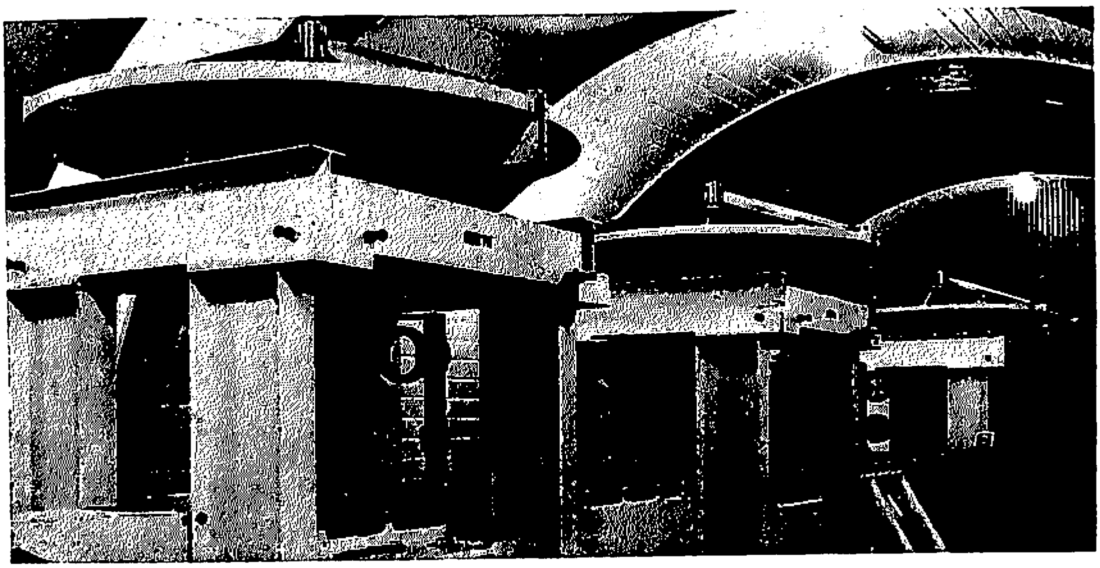

Fig. 2 The Millimeter Wave Array